A48 COLLIMATOR: BEAM PHYSICS JUSTIFICATION AND SIMULATION

Nikolai Mokhov and Alexander Drozhdin
Fermilab

Review of the A48 Collimator Design and Installation Plan

Fermilab

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OUTLINE

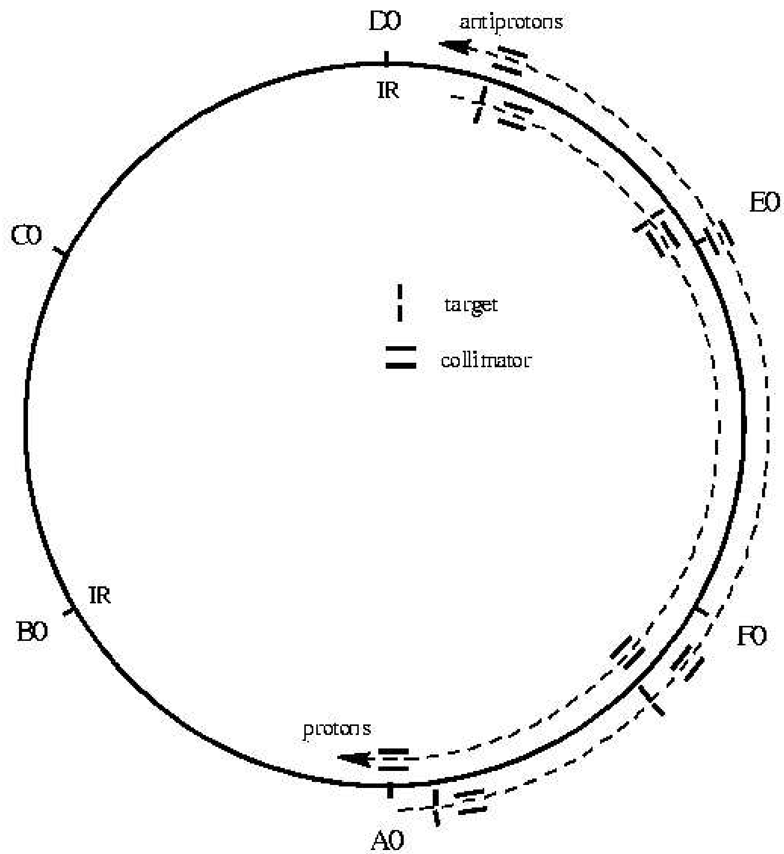
- Physics Motivation
- Monte Carlo Simulations
- Improvements in CDF Losses
- Protection of BØ and CDF at Abort Kicker Prefire (part 2 by AD)

PURPOSE OF COLLIMATION

Beam collimation is mandatory at any superconducting hadron collider to protect components against excessive irradiation, minimize backgrounds in the experiments, maintain operational reliability over the life of the machine (quench stability among other things), and reduce the impact of radiation on environment. It provides:

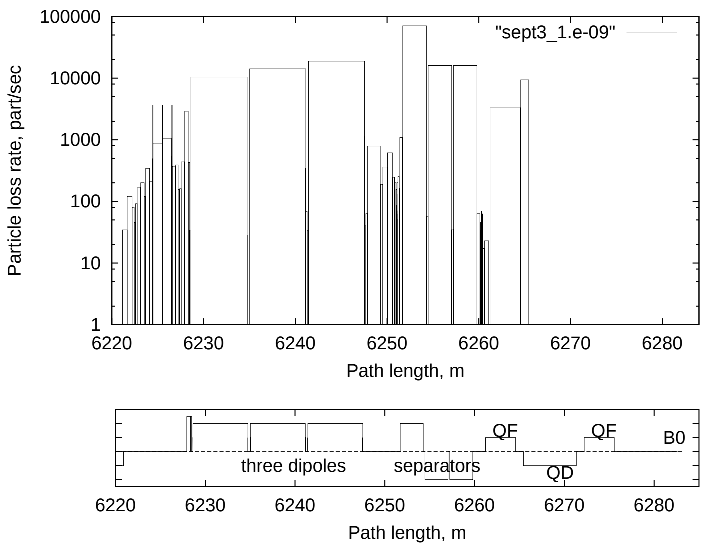
1. Reduction of beam loss in the vicinity of IPs to sustain favorable experimental conditions during the whole store.
2. Minimization of radiation impact on personnel and environment by localizing beam loss in the predetermined regions and using appropriate shielding in these regions.
3. Protection of accelerator components against irradiation caused by operational beam loss and enhancement of reliability of the machine.
4. Prevention of quenching of SC magnets and protection of other machine components from unpredictable abort and injection kicker prefires/misfires and unsynchronized abort.

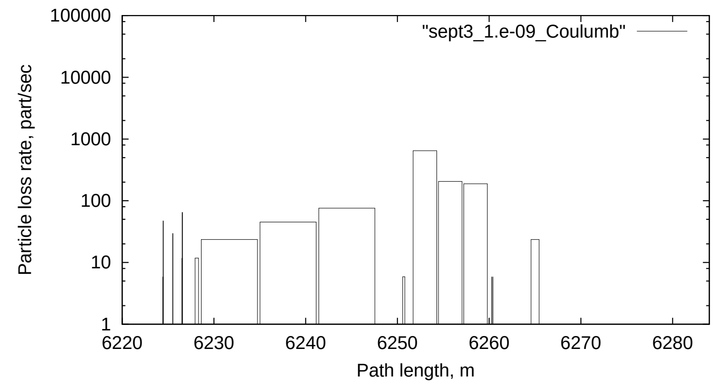
TEVATRON RUN II (1)

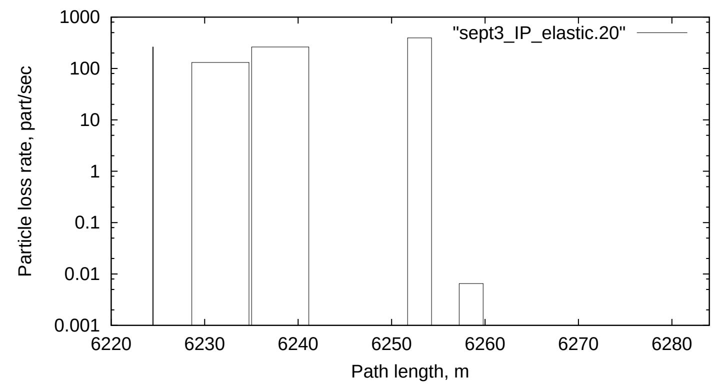


The BØ Roman Pots and low-β quads is the first limiting aperture for the proton beam either **scattered on residual gas** in the AØ – BØ sector or misbehaved due to the **AØ abort kicker prefire**.

BEAM LOSS AT BØ

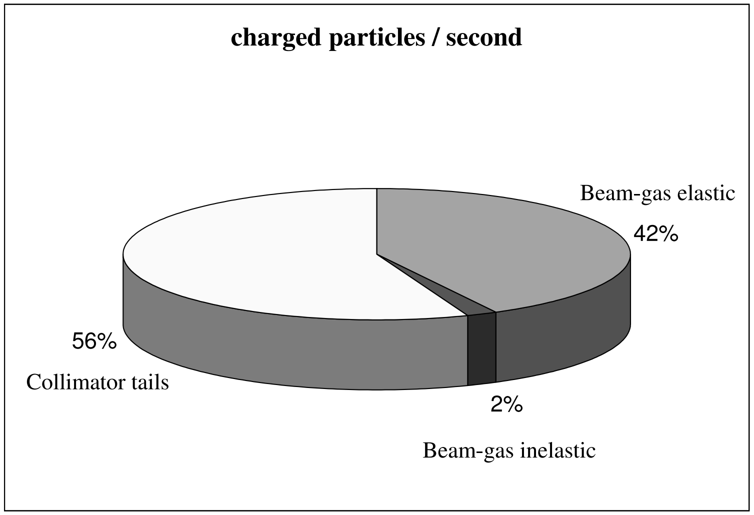


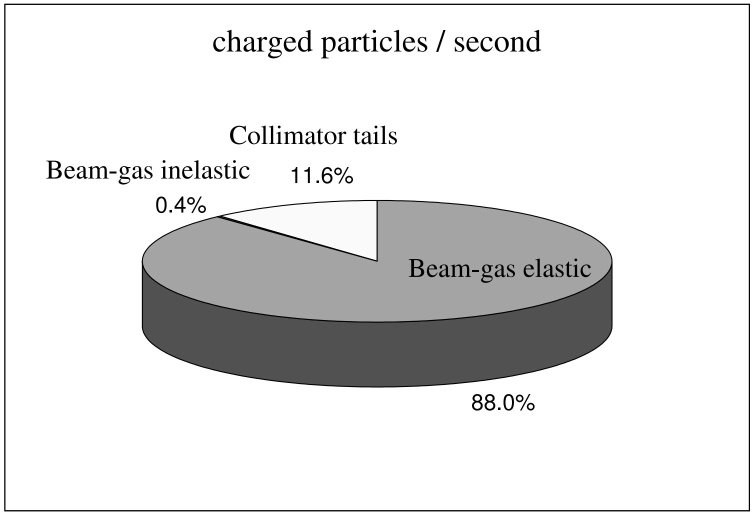




Beam loss distributions upstream of BØfor nuclear elastic beam-gas scattering at uniform gas pressure distribution 10^{-9} torr (left), large angle Coulomb scattering and elastic $p\overline{p}$ interactions at two IPs (right).

CDF BACKGROUNDS

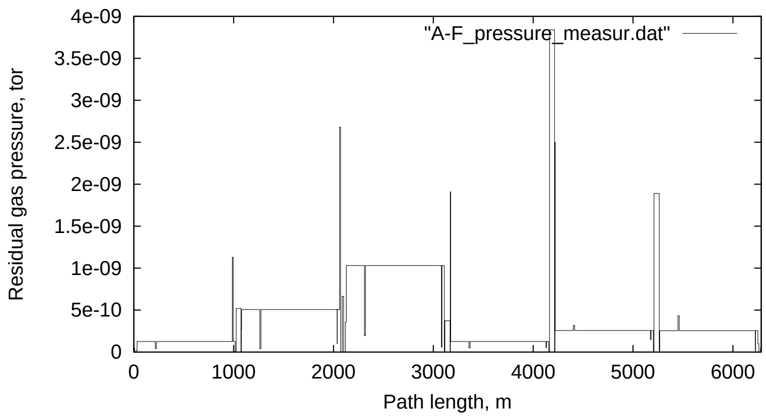


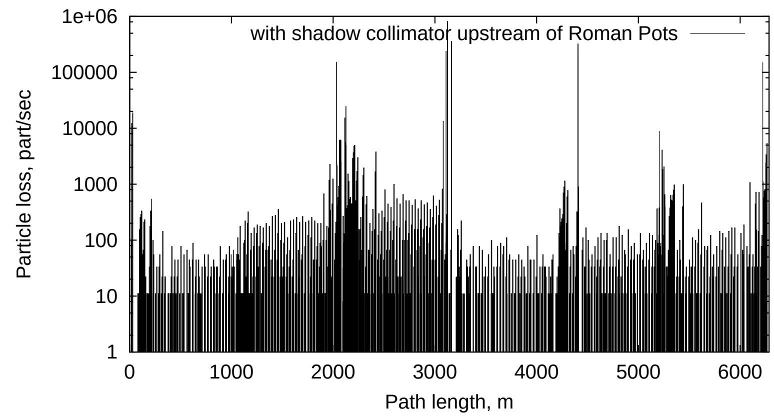


Partial backgrounds at the CDF West Beam Halo Monitors at average pressure in Tevatron of 10^{-10} (left) and 10^{-9} (right) torr.

Beam loss in BØ due to beam-gas elastic scattering exceeds that from tails from the main collimators at $< P > \ \geq 2\times10^{-10}$ torr.

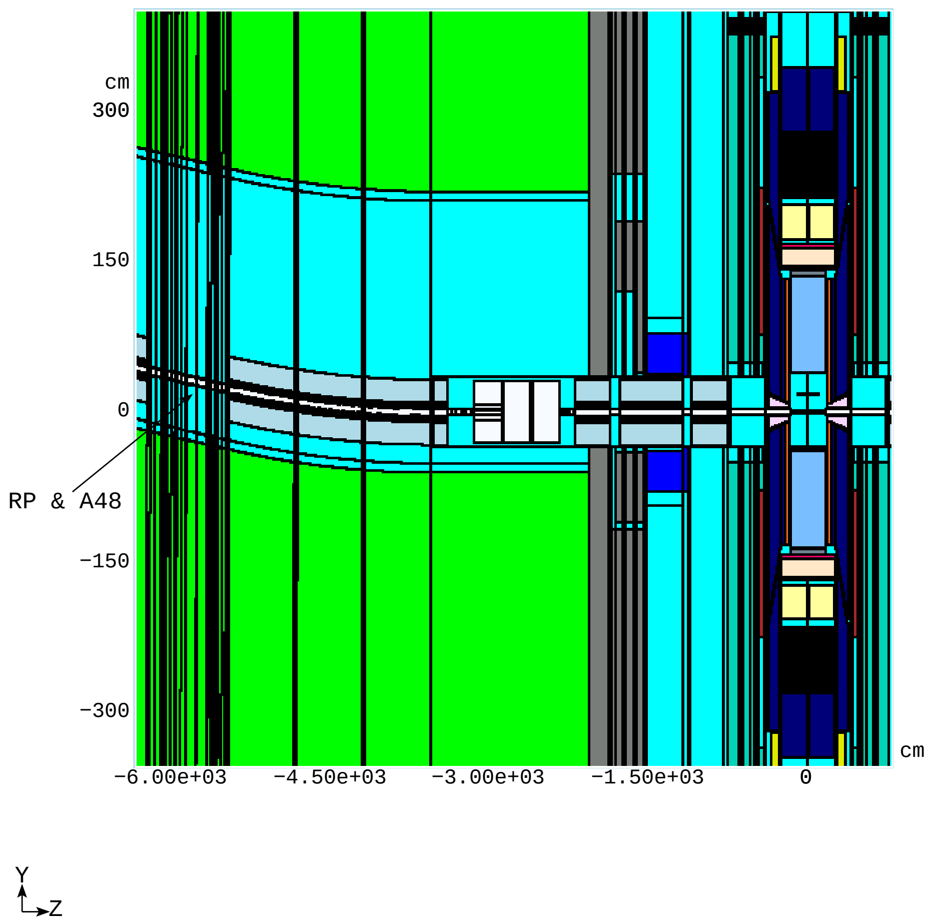
BEAM-GAS SCATTERING IN TEVATRON



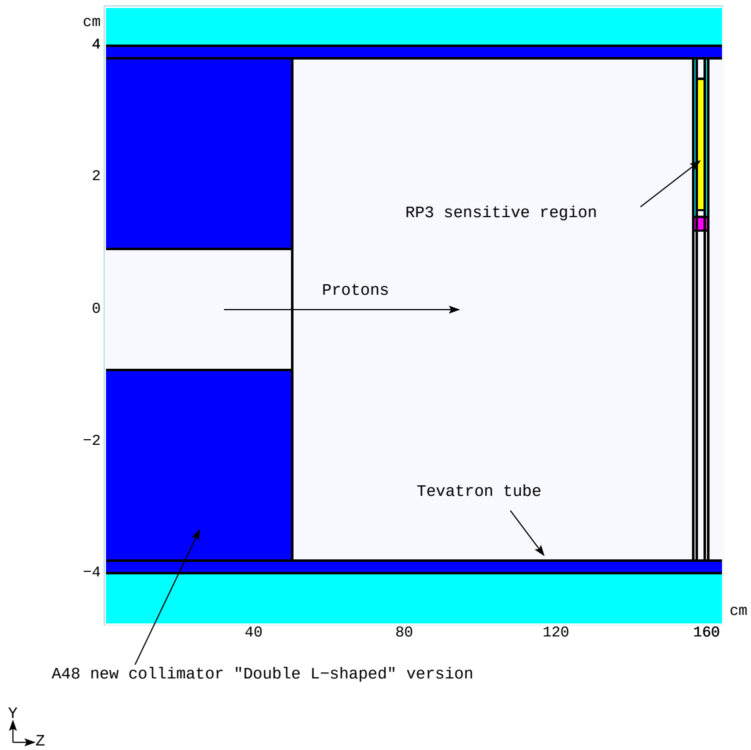


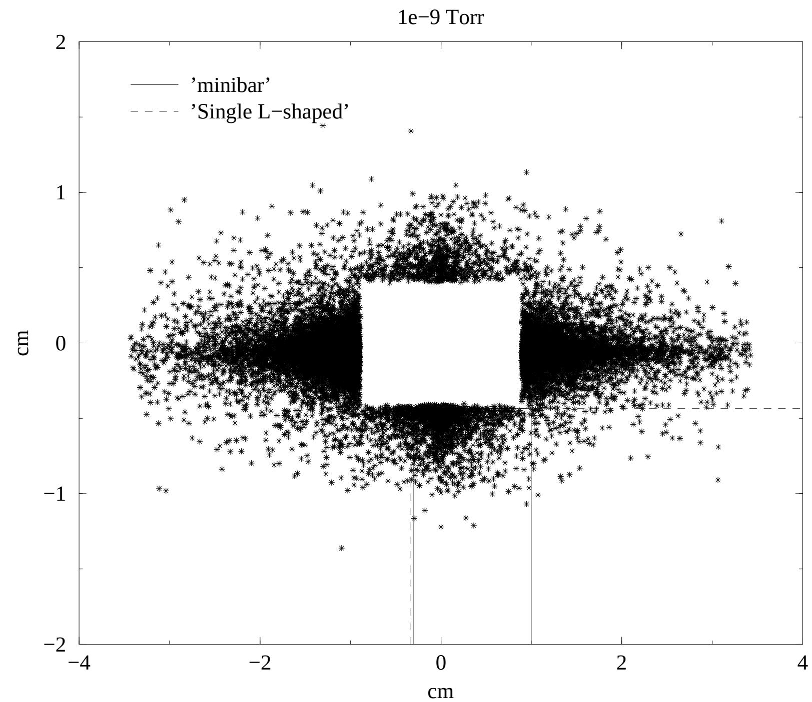
Measured residual gas pressure (*left*) and STRUCT-calculated beam loss distribution from nuclear elastic beam-gas scattering (*right*).

BØ AND CDF MARS MODEL



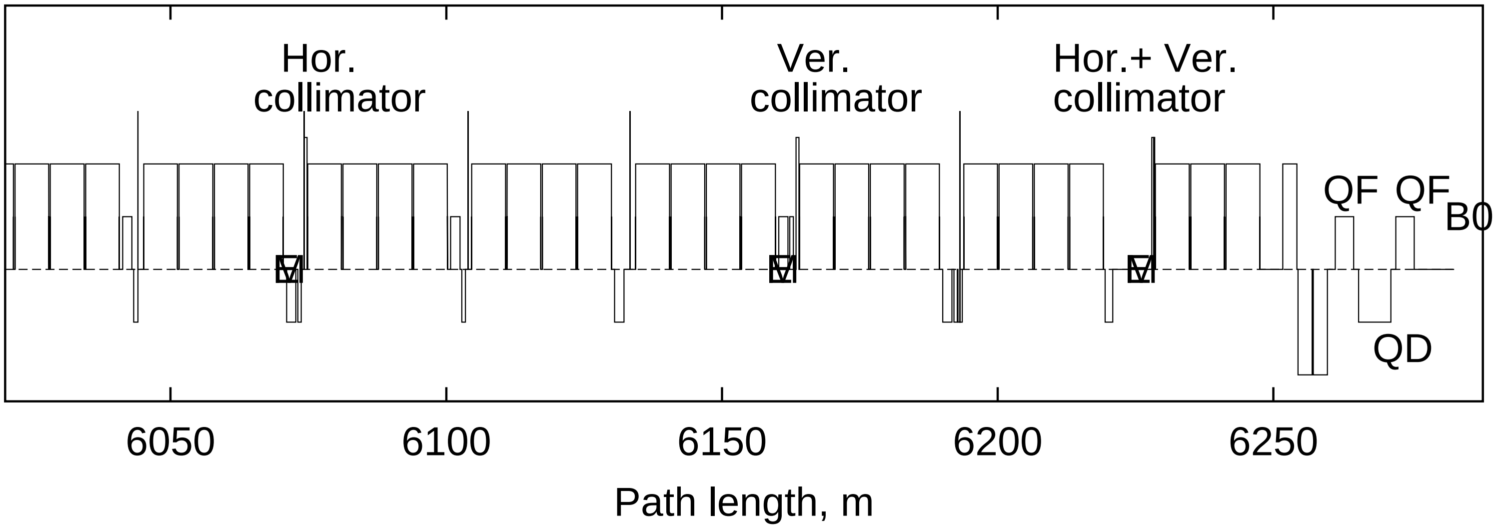
A48 COLLIMATORS (1)





Left: MARS model of the A48-RP3 module. *Right:* Elastic beam-gas (10^{-9} torr) induced proton hits at **"double L-shape"** A48 collimator (entire plot), with lines showing the impact on **"minibar"** and **"single L-shape"** masks.

A48 COLLIMATORS (2)

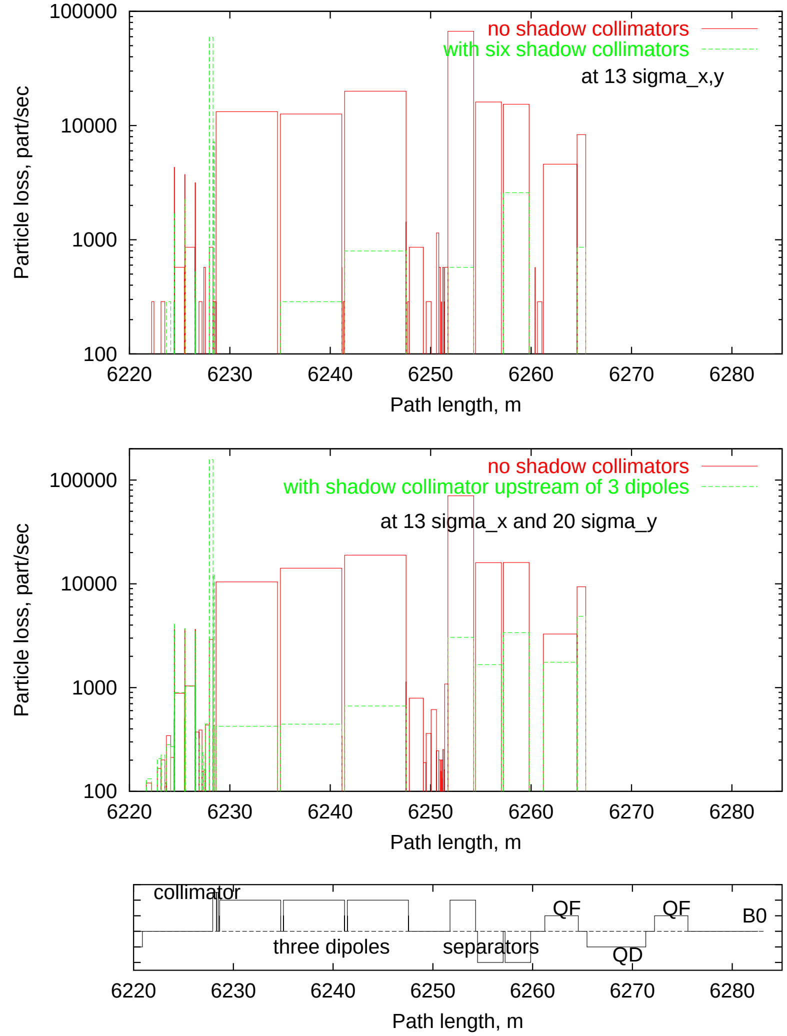


Arrangements of shadow collimators in BØ:

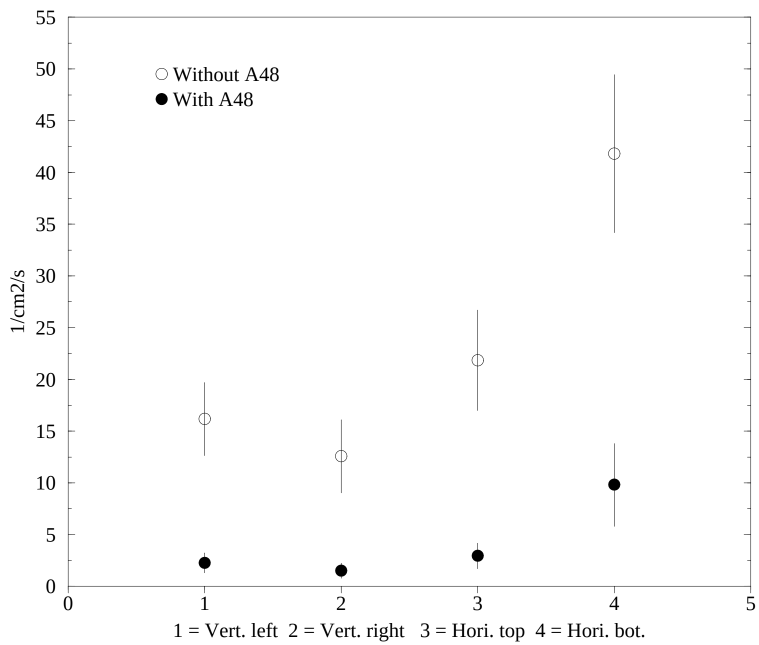
1. H, V and H&V at 13$\sigma_{x,y}$

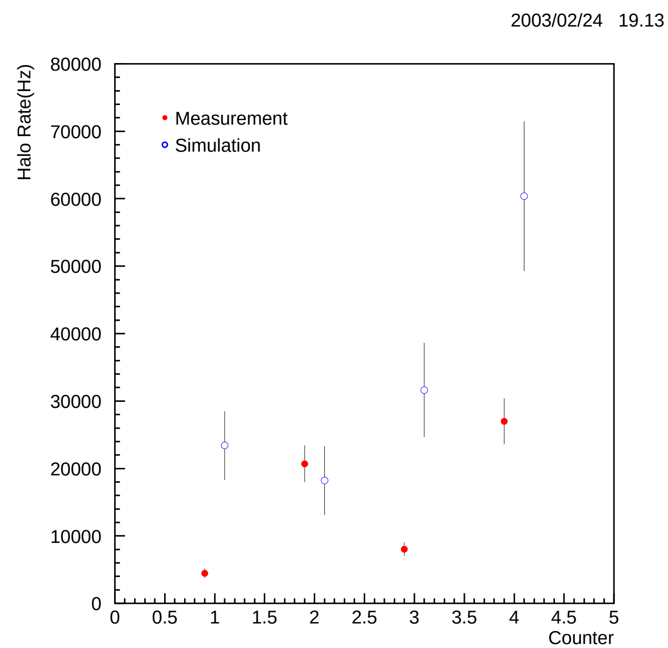
2. H&V at 13σ_x ($\pm$11 mm) and 20σ_y ($\pm$6.3 mm)

BEAM LOSS IN BØ WITH A48 COLLIMATORS



10-FOLD BACKGROUND REDUCTION WITH A48





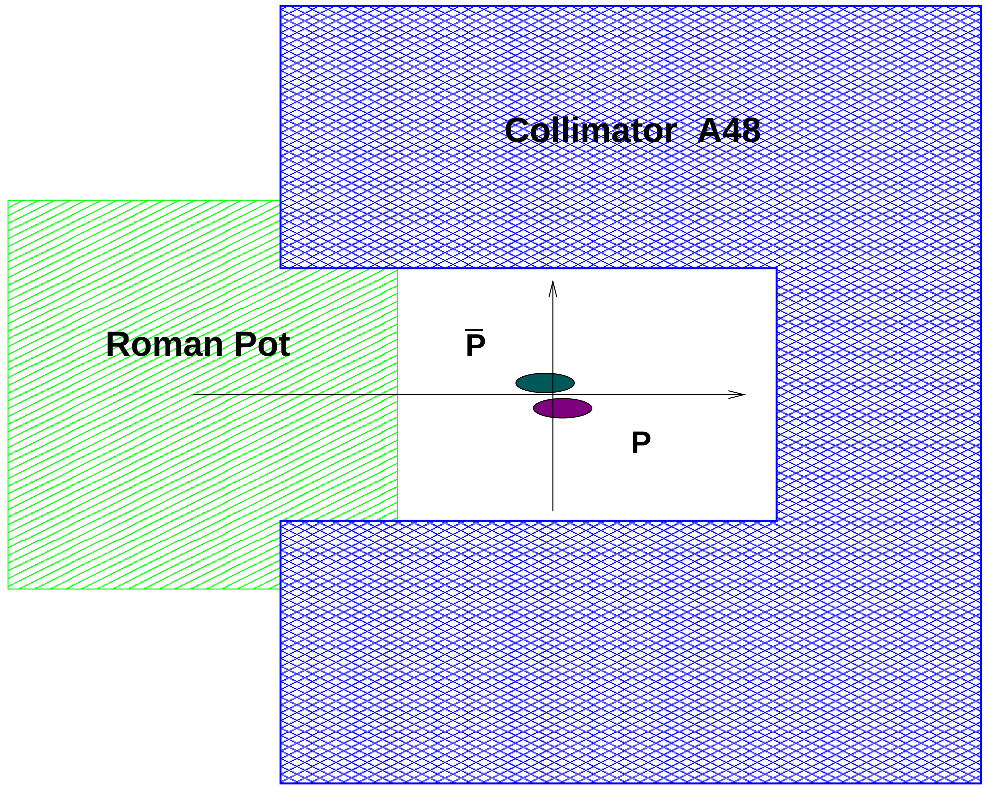
CDF BHM hit rate with and without “double L-shape” A48 collimator (left) and corresponding comparison of MARS calculations with data without the collimator (right).

“Single L-shape” A48 collimator gives a factor of 2 to 3 reduction.

A48 COLLIMATOR AND ROMAN POTS (1)

A BØ shadow collimator installed at $13\sigma_x$ and $20\sigma_y$ at A48 upstream of the last three dipoles would reduce the beam-gas induced backgrounds in the CDF and protect the CDF silicon detectors in an accidental event of an abort kicker prefire (AKP). The optimal positions of such a collimator for a proton beam are x = 9.2 mm and y = 4.4 mm at the non-IP side of the Roman Pots station (upstream RP) or x = 11.1 mm and y = 6.3 mm at the IP side of the RP station (downstream RP). In the last case, the RPs do not suffer from the background generated in the mask by beam halo, but unfortunately, such a mask would decrease the RP horizontal acceptance. Additional concern is the background at RP from secondaries originated in the mask by the antiproton beam halo and antiprotons scattered in the IP to a large angle. This background can not be removed from the statistics as it has the same time as the registered particles. Therefore, the mask in this case can have only three jaws or it should go to the non-IP side of the RP station with the extra background removed from statistic by timing (different time for proton halo and antiprotons scattered in the IP). The protection efficiency of the mask at the IP end of the RP station is several times lower because of its larger aperture.

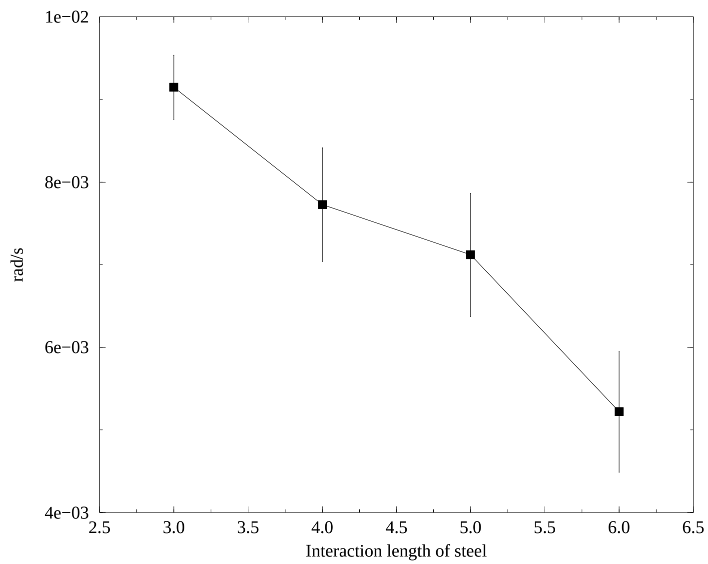
A48 COLLIMATOR AND ROMAN POTS (2)

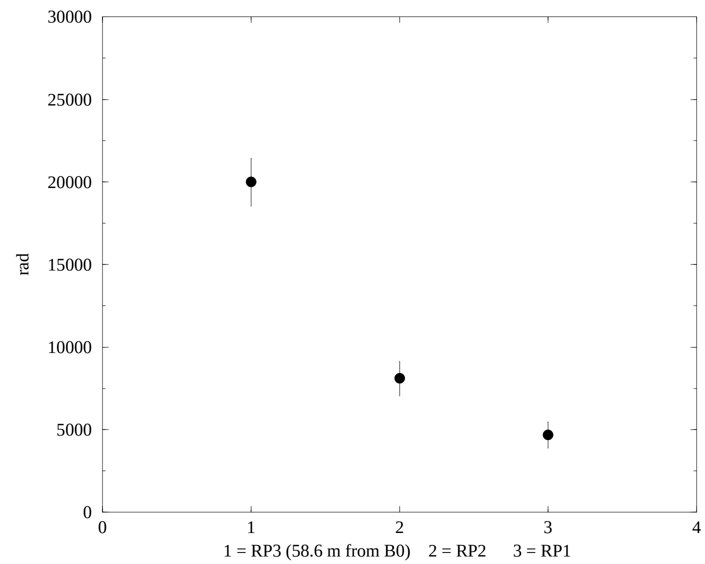


Shadow collimator at the IP end of the Roman Pots station.

The CDF dipole RP set is composed of three detectors one meter apart from each other and starts with RP3 located at 58.6 m from the IP, for an incoming proton. The RP horizontal edge is at 12 mm from the beam pipe axis. The scintillator part of the RP facing the beam is 2×2 cm^2.

A48 COLLIMATOR AND ROMAN POTS (3)

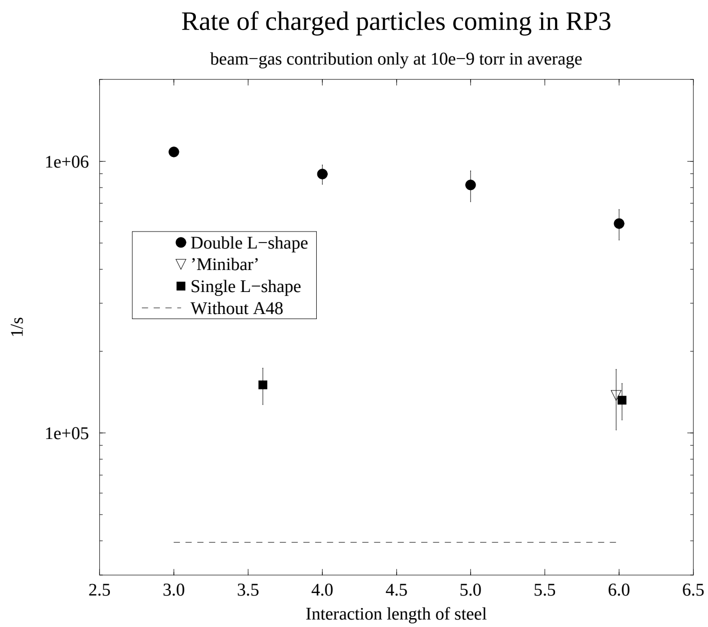


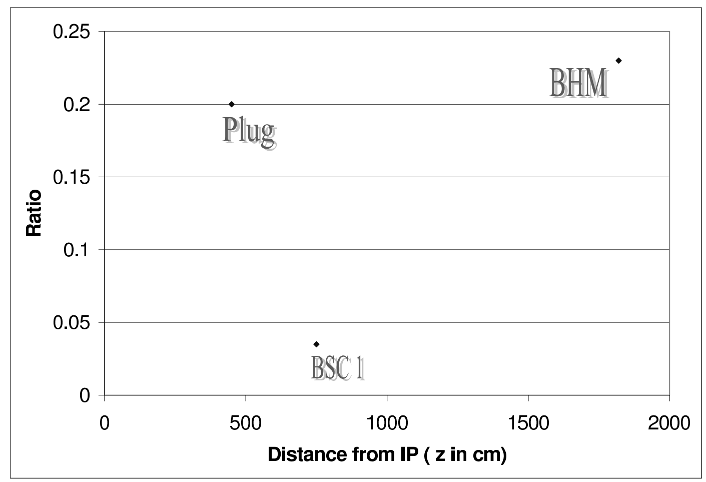


Absorbed dose in RP3 due to beam-gas at 10^{-9} torr (left, D_{max}=100 krad/yr) and dose in RP1-RP3 due to AKP (right, D_{max}=20 krad/event).

A48-induced hit rates in RP: albedo-to-forward ratio is about 0.001.

SUMMARY ON CDF AND RP WITH A48





Rates of charged particles at RP3 as a function of the A48 length for three shapes at 10^{-9} torr average pressure in Tevatron (left) and the main detector absorbed dose ratio with/without "double L-shape" collimator for the elastic contribution as a function of the distance from the IP (right).

CONCLUSIONS ON THE A48 COLLIMATOR

A “single L-shape” A48 collimator at the non-IP end of the CDF RP3 Roman Pots protects the low-β quads and CDF silicon detectors at the AØ abort kicker prefire (see part 2 by AD), reduces backgrounds in the main CDF detector by a factor of 2 to 3, but can increase the halo-induced hit rates in the RP3 by a factor of 3 at average vacuum in the ring of 10^{-9} torr (lower at better vacuum).